FAMU-FSU College of Engineering
Department of Mechanical Engineering

Design for Manufacturing, Reliability, and Economics

EEL4911C/EML4511C– ECE/ME Senior Design Project I

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Introduction

This report conveys the importance of taking into consideration manufacturability, reliability, and cost analysis when designing a product. However, the Robosub team's project was to produce a single product for competition means; not something meant for large scale manufacturing. Reliability and cost analysis however, is very important in any engineering project because being able to afford the components and ensuring that the product actually works is key.

A-Prototype Design and Components

A-1 Selection of Materials and Components

The AUV is made up of many different materials and components all desired for different characteristics. Lightweight, cost, and durability were the main goals in selection.

A-2 Criteria for Major Material Selection

Aluminum 6064 Hull

The hull was chosen to be made out of aluminum 6064 for several reasons. Aluminum 6064 is an inexpensive material, and seeing as the project was on a budget, money was important. Aluminum is also fairly strong being able to withstand accidental bumps during testing and ramming buoys. The aluminum hull additionally offers a decent amount of heat transfer from the cool pool water temperatures to the heat of electronic devices; this will help in avoiding overheating or burnouts.

Acrylic Lid

The acrylic lid was chosen because it allowed visual clarity to the electronic components inside the hull. It had adequate strength to allow the pressures of being underwater and was also able to be machined fairly easily using a waterjet.

80-20 Aluminum Railing

The 80-20 aluminum railing was again used because of it's strength, and extreme versatility. Its ability to be able to mount components in various secure position was vital to creating a lightweight and sturdy AUV.

A-3 Schematics, Bill of Materials, and Specs

Name:	Quantity:	Name:	Quantity:
BOX BASE	1	CLAW NUT	1
BOX FRONT	2	CLAW REL ADPT	1
BOX SIDES	2	CLAW PIN LONG	1
8020 27" long	2	CLAW ARM VALVE CONNECTOR	2
8020 4.5" long	11	CLAW ARM	2
8020 13" long	4	CLAW RELEASE BLOCK	1
THRUSTERS	6	FLANGE 21" long	2
8020 3" long	2	FLANGE 14" long	2
THRUSTER PLACE PLATE WIDE	2	BOX TOP	1
CAMERA HOUSING SIDES	2	ARM BRACKET TORPEDO LAUNCHER	2
CAMERA HOUSING SHELL FRONT	2	CONNECTOR TORPEDO LAUNCHER	2
CAMERA HOUSING CAP	2	AIR PISTON TORPEDO LAUNCHER	2
CAMERA STAND	2	BARREL TORPEDO LAUNCHER	2
CAMERA STAND CON	2	TORPEDO TORPEDO LAUNCHER	2
CAMERA	2	AIR TANK ANGLE	1
MARKER ANGLE	1	AIR TANK BOTTOM CAP	1
MARKER PLATE	2	AIR TANK	1
MARKER SCREW	4	FLANGED BOLT PARTIAL 1/4"	12
MARKER SCREW TUBE	12	NUT 1/4"	12
MARKER CHANNEL	4	O-RING 1/4" diameter 20" long	1
MARKER SERVO	1	ACTUATOR	4
8020 6" long	1	SEACON 3 PRONG	9
8020 2.75" long	1	SEACON 6 PRONG	2
CLAW ANGLE	1	SEACON 4 PRONG	1
CLAW PISTON	1	SEACON 5 PRONG	4

A-4 Assembly Drawings

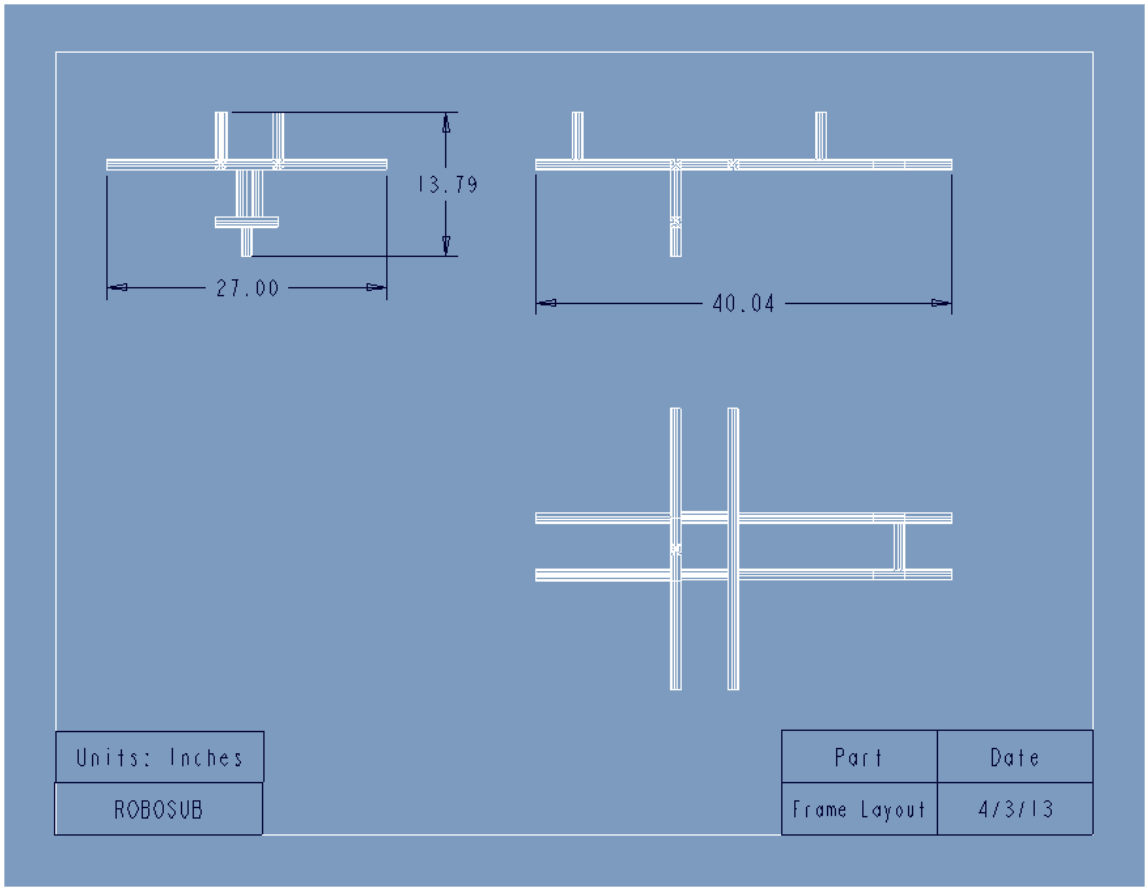

Figure 1: Pro E model of frame

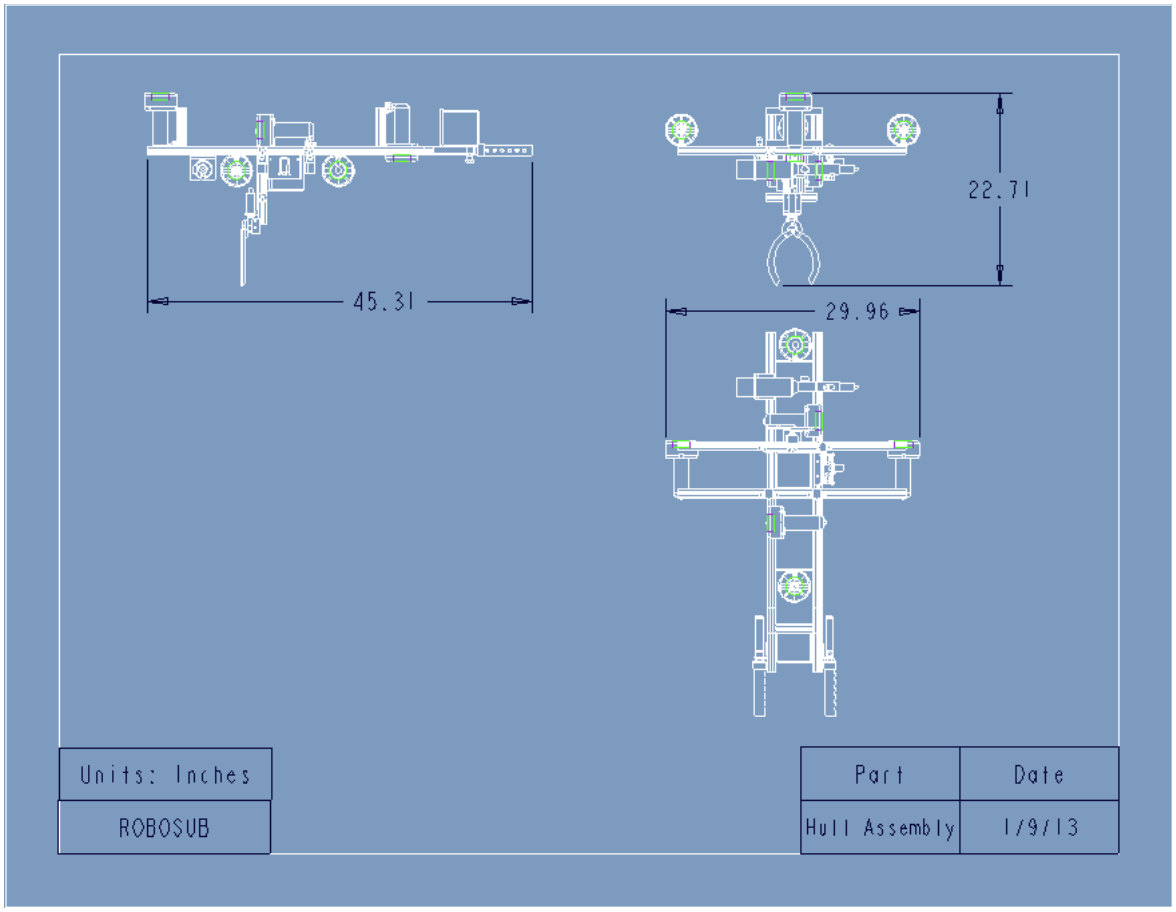

Figure 2: Pro E model of frame with components

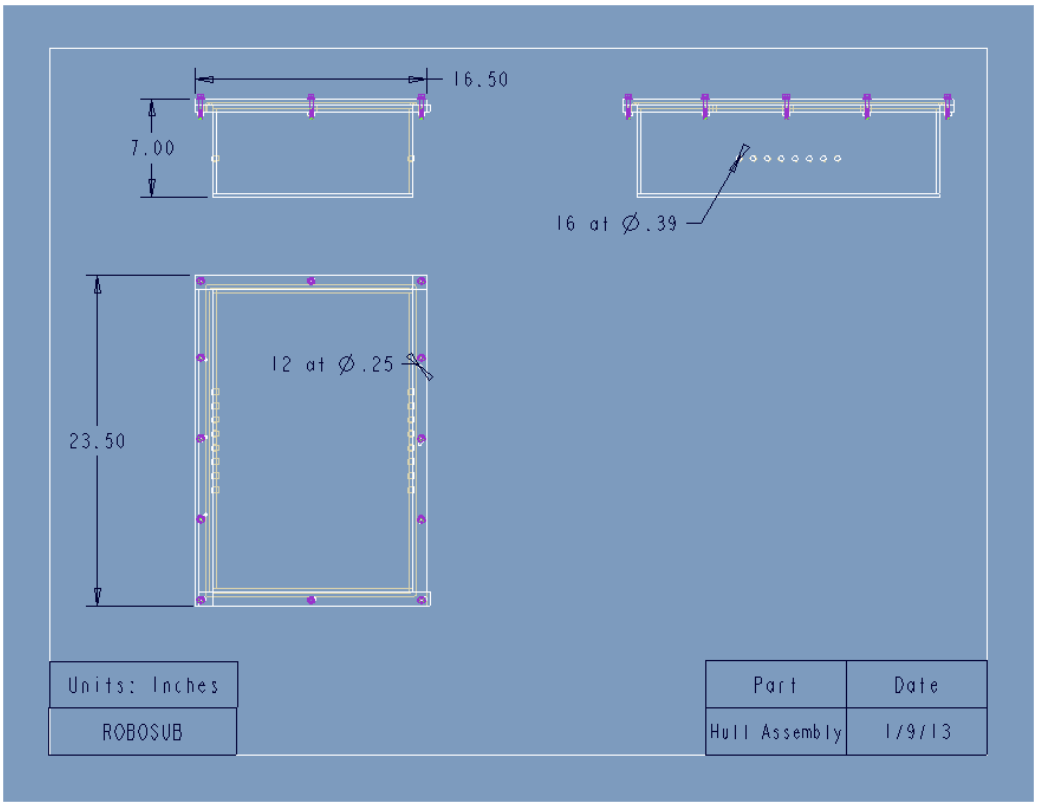

Figure 3: Pro E model of Hull

B-Design for Reliability

B-1 Safety Factors

Safety needs to be taken into consideration when designing an almost 90 lb robotic submarine. The AUVSI competition requires a kill switch that when flipped cuts all power to the AUV rendering it dead in the water. Safety shrouds over the propellers of the thrusters allow no possible injury from them.

B-2 Potential Failure Modes

The AUV has several ways that could cause failure of operation. The main potential failure mode is if leak occurs and water enters the hull causing damage and possibly ruining the computer and electronics of the AUV. Breaking or burning out some of the motor controllers or electronic boards would ruin the system and cause failure. Extreme damage to thrusters or other external components to the AUV, either during transportation, testing, or competition will cause failure to the AUV system.

B-3 Long term maintenance and usage

In order to reuse the AUV proper usage and maintenance is required. Careful handling of electronic components will ensure no accidental damage by human error. Rinsing off water that has chemicals, salt water or pool water, from the AUV after every use and drying it off will reduce the chances of corrosion of the exterior hull and nuts and bolts to the components.

C-Design for Economics

In deciding an approach to make construction of the submarine as economic as possible, different things were evaluated. In the selection of materials, research was done to see what the cheapest materials that could outperform certain specifications. Things such as density of the material vs. the cost of the material were looked at. Similar processes were used for all the electronic component selections as well.

C-1 Material Costs

The costs associated with building materials for the AUV came to a total of $543.80. This includes all the aluminum panels that were bought for both the prototype hull as well as the final hull, the acrylic bought for the lid, and the rest of the hull parts such as bolts, nuts, o-rings, and clamps.

The electronic components that were bought for the system came to a total of $825.23. This covered the new computer for the system, all the batteries required to power the system, the Arduino and Arduino Mega boards, the IMU, and replacement motor drivers.

Expense Report		
Purchases	EE	
	Z-box	331.70
	Arduinos	50.00
	Batteries	185.90
	RAM	35.97
	IMU	124.95
	Arduino Mega	58.95
	Motor Drivers	
	ME	
	Al-panels	15.40
	Orings/clamps/acrylic	90.98
	Al-panels	20.11
	Hull materials	417.31
	Comp. Registration	500
Funds Left	331.97	

Figure 4: Expense Report

C-2 Manufacturing Costs

The team did not have to set aside money for the manufacturing of the hull for the project, as all of the work on the hull was done in the school's machine shop. If the work had to be taken to an outside machine shop, however, the cost would have been about $600 (assuming a rate of $80/hour and 8 hours of work).

C-3 Testing Costs

Since most of the testing that needed to be done on the AUV was done either in the lab or in the Morcom Aquatics Center, the team faced no expenses for testing the project.

C-4 Competition Costs

To be able to compete, the team paid $500 for the competition registration. For travel, at a rate of $500 per person for airfare, and $150 per night for a hotel room at the competition, the cost would be $4400 for the whole team. This is assuming 7 travelers, and 2 hotel rooms for 3 nights.